CLAIMS

1. An electrode metal material for using in an electrode structure in contact with non-aqueous electrolyte, wherein the electrode metal material is a carbon-containing metal material comprising a valve metal material and numerous carbon particles fixed in a surface of the valve metal material and exposed to the surface thereof.

2. The electrode metal material according to claim 1, wherein said carbon particles are projected from the surface of said valve metal material to expose to said surface.

3. The electrode metal material according to claim 1, wherein the metallic surface of said carbon-containing metal material is coated with a passive film.

4. The electrode metal material according to claim 1, wherein said electrode metal material is coated with an activated carbon layer to form a double-layer electrode for an electric double-layer capacitor.

5. The electrode metal material according to claim 1, wherein said electrode metal material is a cathode of an electrolytic capacitor, making contact with non-aqueous electrolyte.

6. The electrode metal material according to Claim 1, wherein said electrode metal material is thin sheet.

7. The electrode metal material according Claim 1, wherein said carbon particles are formed of conductive carbon particles, such as graphite or carbon black.

8. The electrode metal material according to Claim 1, wherein said carbon particles are activated carbon particles.

9. The electrode metal material according to Claim 1, wherein said carbon particles have a mean diameter of the range of 0.01 to 50 μm.

10. The electrode metal material according to Claim 1, wherein said carbon particles have one of particulate, granular and fibrous forms.

11. A method of producing an electrode metal material, being a carbon-containing metal material comprising a valve metal material and numerous carbon particles fixed in at least a surface of said valve metal material and exposed to said surface, wherein said method comprises the steps of:

including said carbon particles in a valve metal ingot by heating and pressurizing a mixture of valve metal powder and carbon powder in a container; and,

forming said obtained valve metal ingot into a desired shape so as to be used as said carbon-containing metal material.

12. A method of producing an electrode metal material, being a carbon-containing metal material comprising a valve metal material fixed numerous carbon particles in at least a surface thereof, wherein said method comprises: dispersing carbon particles on the surface of a valve metal material; and embedding the carbon particles into the surface of said valve metal material by pressurizing said carbon particles onto the surface of said valve metal material to obtain said carbon-containing metal material.

13. The method of producing an electrode metal material according to claim 11, wherein said carbon embedding step uses a press method in which said carbon particles are driven

by using a die.

14. The method of producing an electrode metal material according to claim 11, wherein said carbon embedding step uses a rolling method in which said carbon particles are driven by using a roller.

15. The method of producing an electrode metal material according to claim 11, wherein said carbon embedding step is carried out when said valve metal material is formed by hot or cold working.

16. The method of producing an electrode metal material according to Claim 11, wherein the method comprises a step of coarsening the surface of said carbon-containing metal material.

17. The method of producing an electrode metal material according to Claim 11 or 12, wherein the method further comprises a further step of exposing said carbon particles to the surface of said carbon-containing metal material by etching said carbon-containing metal material in an acidic aqueous solution.

18. The method of producing an electrode metal material according to Claim 11 or 12, wherein the method comprises a step of exposing said carbon particles to the surface of said carbon-containing metal material by blasting said carbon-containing metal material.

19. The method of producing an electrode metal material according to claim 17, wherein the method comprises a step of forming a passive film on the metallic surface of said carbon-containing metal material after said step of exposing said carbon particles.

20. The method of producing an electrode metal material according to Claim 11 or 12, wherein said carbon particles are formed of conductive carbon particles, such as graphite or carbon black.

21. The method of producing an electrode metal material according to Claim 11 or 12, wherein said carbon particles are activated carbon particles.

22. The method of producing an electrode metal material according to Claim 11 or 12, wherein the diameter of said carbon particles is in the range of 0.01 to 50 μm.

23. The method of producing an electrode metal material according to Claim 11 or 12, wherein said carbon particles have one of particulate, granular and fibrous forms.

24. A capacitor comprising a pair of electrodes and non-aqueous electrolyte, wherein at least one electrode includes an electrode metal material which is a carbon-containing metal material comprising a valve metal material and numerous carbon particles fixed in the surface of said valve metal material and exposed to said surface.

25. The capacitor according to claim 24, wherein said capacitor is an electric double-layer capacitor, and said pair of electrodes is formed of electric double-layer electrodes each comprising said carbon-containing metal material and an activated carbon layer formed in contact with said carbon particles on the surface of said metal material.

26. The capacitor according to claim 25, wherein said valve metal material is a flexible sheet, said pair of electric double-layer electrodes is disposed face-to-face with a separator therebetween and wound, and enclosed in a

container to obtain a winding type electric double-layer capacitor.

27. The capacitor according to claim 25, wherein said activated carbon layers of said pair of electric double-layer electrodes are accommodated in a container with a separator therebetween, and said valve metal materials of said electrodes are accommodated in the metallic lid and bottom portions of a container, which are coupled so as to be insulated from each other.

28. The capacitor according to claim 27, wherein said metallic lid and bottom portions of said container are clad with said valve metal materials.

29. The capacitor according to claim 24, wherein said capacitor is an electrolytic capacitor, one of said electrode metal materials is used as the cathode, and the other electrode metal material having a dielectric insulating film is used as the anode.

30. The capacitor according to Claim 24, wherein said carbon particles are formed of conductive carbon particles, such as graphite or carbon black.

31. The capacitor according to Claim 24, wherein said carbon particles are activated carbon particles.

32. The capacitor according to Claim 24, wherein the diameter of said carbon particles is in the range of 0.01 to 50 μm.

33. The capacitor according to Claim 24, wherein said carbon particles have one of particulate, granular and fibrous forms.

34. The capacitor according to Claim 24, wherein a

passive film is formed on the metallic surface of said valve metal material.

35. A method of producing an electric double-layer capacitor comprising a pair of electric double-layer electrodes each formed of an activated carbon layer formed on the surface of a valve metal material, a separator for separating said pair of electric double-layer electrodes and non-aqueous electrolyte, wherein said method comprises the steps of:

forming a carbon-containing metal material in which numerous carbon particles are fixed in at least a the surface of a valve metal material and exposed to said surface;

applying a paste containing activated carbon particles to the surface of said carbon-containing metal material; and

drying and curing said paste to obtain said electric double-layer electrodes.

36. The method of producing a capacitor according to claim 35, wherein, after the step of forming said carbon-containing metal material, said method further comprises a step of exposing said carbon particles on the surface of said metal material by electrolytic etching said metal material in an acidic aqueous solution.

37. A method of producing a button-type electric double-layer capacitor in which a pair of electric double-layer electrodes, each having an activated carbon layer formed on the surface of an electrode metal material, is accommodated in a container with the activated carbon layers laminated via a separator therebetween, and the electrode metal materials are coupled to the metallic lid and bottom

portions of the container, both portions being insulated from each other, wherein said method comprises the steps of;

forming a carbon-containing metal material, as the electrode metal material, in which numerous carbon particles are included at least in the surface of a valve metal material and exposed to said surface; and

applying the activated carbon layers to the surfaces of the valve metal materials to obtain the electric double-layer electrodes.

38. The method of producing an electric double-layer capacitor according to claim 37, including a step of previously carrying out cladding of the metallic bottom portion of said container with said valve metal materials at so as to accomplish integration.

39. A method of producing an electrolytic capacitor in which an anode formed of a valve metal material having a dielectric insulating film on the surface thereof and a cathode formed of a valve metal material are disposed face-to-face in non-aqueous electrolyte, wherein said method comprises a steps of forming a carbon-containing metal material in which numerous carbon particles are fixed in at least a surface of the valve metal material and exposed to said surface so that the carbon-containing metal material is used as the electrode metal material for the cathode.

40. The method of producing a capacitor according to claim 35, 37 or 39, wherein the step of forming the carbon-containing metal material includes a carbon embedding step of driving the carbon particles into the surface of the valve metal material by pressurizing the carbon particles dispersed

on the surface of said valve metal material to obtain the carbon-containing metal material.

41. The method of producing a capacitor according to claim 40, wherein said carbon embedding step uses a press method in which said carbon particles are driven by using a die.

42. The method of producing a capacitor according to claim 40, wherein said carbon embedding step uses a rolling method in which the carbon particles are driven by using rollers.

43. The method of producing a capacitor according to claim 41, wherein said carbon embedding step is carried out in a hot or cold working step to form the valve metal material.

44. The method of producing an electrode metal material according to claim 40, including a step of coarsening the surface of said carbon-containing metal material.

45. The method of producing an electrode metal material according to claim 40, wherein the method further includes a step of exposing said carbon particles to the surface of the carbon-containing metal material by electrolytically etching the surface of the carbon-containing metal material in an acidic aqueous solution.

46. The method of producing an electrode metal material according to Claim 40, wherein the method further includes a step of exposing said carbon particles to the surface of the carbon-containing metal material by blasting the carbon-containing metal material.

47. The method of producing an electrode metal material

according to claim 45, wherein the method further includes a step of forming a passive film on the metallic surface of the carbon-containing metal material after said carbon particle exposing step.

48. The method of producing an electrode metal material according to Claim 41, wherein said carbon particles are formed of conductive carbon particles, such as graphite or carbon black.

49. The method of producing a capacitor according to claim 42, wherein said carbon embedding step is carried out in a hot or cold working step to form the valve metal material.

50. The method of producing an electrode metal material according to Claim 42, wherein the method further includes a step of exposing said carbon particles to the surface of the carbon-containing metal material by blasting the carbon-containing metal material.

51. The method of producing an electrode metal material according to Claim 43, wherein the method further includes a step of exposing said carbon particles to the surface of the carbon-containing metal material by blasting the carbon-containing metal material.

52. The method of producing an electrode metal material according to Claim 42, wherein said carbon particles are formed of conductive carbon particles, such as graphite or carbon black.

53. The method of producing an electrode metal material according to Claim 43, wherein said carbon particles are formed of conductive carbon particles, such as graphite or

carbon black.

54. A non-aqueous secondary battery comprising a positive electrode and a negative electrode and non-aqueous electrolyte to make contact to both the electrodes therein, wherein the positive electrode is formed on an electrode metal material which is a carbon-containing metal material comprising a valve metal material and numerous carbon particles fixed in and exposed to a surface of the valve metal material.

55. The non-aqueous secondary battery according to Claim 54, wherein the electrode metal material is a clad material comprising the carbon-containing metal material and a base metal plate.

56. The non-aqueous secondary battery according to Claim 54, wherein a passive film thicker than a film to be naturally oxidized is formed on the metallic surface of the valve metal material.

57. The non-aqueous secondary battery according to Claim 56, wherein the passive film has higher withstand voltage than 3V.

58. The non-aqueous secondary battery according to Claim 54, wherein the base metal is nickel or stainless steel.

59. A method for producing a non-aqueous secondary battery comprising: a positive electrode; a negative electrode; and non-aqueous electrolyte to make contact with both the electrodes therein, wherein the method comprises: forming a carbon containing electrode metal material by embedding carbon particles into the surface of a sheet of valve metal material, the carbon particles exposing on the

surface of the sheet; and applying a paste containing positive active substance on the carbon containing electrode metal material for producing the positive electrode.

60. The method according to Claim 59, wherein the method further includes cladding the carbon containing electrode metal material on a base metal plate in order to embed the carbon particles on the surface of the sheet.

61. The method according to Claim 59, wherein the method further includes previously cladding a sheet of the valve metal material on a base metal plate to produce a clad which is embedded with the carbon particles.

62. The method according to Claim 60, wherein the method further includes form a passive film on the surface of the carbon containing ~~electrode metal material~~.

63. The method according to Claim 63, wherein the ~~passive film is formed by anodizing the carbon~~ containing electrode metal material.

64. The method of an electrode metal material according to Claim 13, wherein in the step of dispersing carbon particles, a slurry containing the carbon particles is applied to the surface.

65. The method according to Claim 64, wherein the slurry containing the carbon particles and solvent, without containing a binder.

66. The method according to Claim 64, wherein the method includes drying the slurry after applying on the valve metal material.

67. The method according to Claim 64, wherein the valve metal material is roughened on the surface.

68. The method according to Claim 67, wherein the roughening of the valve metal material is performed by electrolytically etching.

69. The method according to Claim 67, wherein the roughening of the valve metal material is performed by chemically etching.

70. The method according to Claim 67, wherein the roughening of the valve metal material is performed by blasting technique .

71. The method according to claim 64, wherein said carbon embedding step uses a press method in which said carbon particles are driven by using a die.

72. The method of producing an electrode metal material according to claim 64, wherein said carbon embedding step uses a rolling method in which said carbon particles are driven by using a roller.

73. The method of producing an electrode metal material according to claim 72, wherein the roller is an roller embossed on its surface.

74. The method of producing an electrode metal material according to Claim 64, wherein the method comprises a step of coarsening the surface of said carbon-containing metal material.

75. The method of producing an electrode metal material according to Claim 64, wherein the method further comprises a further step of exposing said carbon particles to the surface of said carbon-containing metal material by etching said carbon-containing metal material in an acidic aqueous solution.

76. The method of producing an electrode metal material according to Claim 64, wherein the method comprises a step of exposing said carbon particles to the surface of said carbon-containing metal material by blasting said carbon-containing metal material.

77. The method of producing an electrode metal material according to claim 75, wherein the method comprises a step of forming a passive film on the metallic surface of said carbon-containing metal material after said step of exposing said carbon particles.

78. The method of producing an electrode metal material according to Claim 77, the step of forming a passive film includes heat treating of the carbon-containing electrode material in air.

79. The method of producing an electrode metal material according to Claim 78, the heat treating is performed at 300 - 620℃.

80. The method of producing an electric double-layer capacitor according to Claim 35, wherein in the step of forming the carbon-containing metal material, a slurry containing the carbon particles is applied to the surface of the valve metal material, dried and drive into the surface of the valve metal material by pressing.

81. The method according to Claim 80, wherein the slurry containing the carbon particles and solvent, without containing a binder.

82. The method according to Claim 80, wherein the method includes drying the slurry after applying on the valve metal material.

83. The method according to Claim 80, wherein the valve metal material is roughened on the surface.

84. The method according to Claim 83, wherein the roughening of the valve metal material is performed by electrolytically etching.

85. The method according to Claim 83, wherein the roughening of the valve metal material is performed by chemically etching.

86. The method according to Claim 83, wherein the roughening of the valve metal material is performed by blasting.

87. The method according to claim 80, wherein said carbon embedding step uses a press method in which said carbon particles are driven by using a die.

88. The method of producing an electric double-layer capacitor according to claim 80, wherein said carbon embedding step uses a rolling method in which said carbon particles are driven by using a roller.

89. The method of producing an electric double-layer capacitor according to claim 88, wherein the roller is an roller embossed on its surface.

90. The method of producing an electric double-layer capacitor according to Claim 80, wherein the method comprises a step of coarsening the surface of said carbon-containing metal material.

91. The method of producing an electric double-layer capacitor according to Claim 80, wherein the method further comprises a further step of exposing said carbon particles to the surface of said carbon-containing metal material by

etching said carbon-containing metal material in an acidic aqueous solution.

92. The method of producing an electric double-layer capacitor according to Claim 80, wherein the method comprises a step of exposing said carbon particles to the surface of said carbon-containing metal material by blasting said carbon-containing metal material.

93. The method of producing a capacitor according to claim 80, wherein, after the step of forming said carbon-containing metal material, said method further comprises a step of exposing said carbon particles on the surface of said metal material by electrolytic etching said metal material in an acidic aqueous solution.

94. A method of producing a button-type electric double-layer capacitor according to Claim 80, wherein in the step of forming the carbon-containing metal material, a slurry containing the carbon particles is applied to the surface of the valve metal material, dried and embedded into the surface of the valve metal material by pressing.

95. The method of producing an electric double-layer capacitor according to claim 94, wherein the method further including a step of previously cladding of the metallic bottom portion of said container with said valve metal materials at so as to accomplish integration.

96. The method according to Claim 94, wherein the slurry containing the carbon particles and solvent, without containing a binder.

97. The method according to Claim 94, wherein the method includes drying the slurry after applying on the valve

metal material.

98. The method according to Claim 94, wherein the valve metal material is roughened on the surface.

99. The method according to Claim 98, wherein the roughening of the valve metal material is performed by electrolytically etching.

100. The method according to Claim 98, wherein the roughening of the valve metal material is performed by chemically etching.

101. The method according to Claim 98, wherein the roughening of the valve metal material is performed by blasting sand technique .

102. The method according to claim 94, wherein said carbon embedding step uses a press method in which said carbon particles are driven by using a die.

103. The method of producing a button-type electric double-layer capacitor according to claim 94, wherein said carbon embedding step uses a rolling method in which said carbon particles are driven by using a roller.

104. The method according to claim 72, wherein the roller is an roller embossed on its surface.

105. The method of producing a button-type electric double-layer capacitor according to Claim 94, wherein the method comprises a step of coarsening the surface of said carbon-containing metal material.

106. The method of producing a button-type electric double-layer capacitor according to Claim 94, wherein the method further comprises a further step of exposing said carbon particles to the surface of said carbon-containing

metal material by etching said carbon-containing metal material in an acidic aqueous solution.

107. The method of producing a button-type electric double-layer capacitor according to Claim 94, wherein the method comprises a step of exposing said carbon particles to the surface of said carbon-containing metal material by blasting said carbon-containing metal material.

108. A method of producing an electrolytic capacitor according to claim 39, wherein in the step of forming a carbon-containing metal material, a slurry containing the carbon particles is applied to the surface of the valve metal material, dried and drive into the surface of the valve metal material by pressing.

109. The method according to Claim 108, wherein the method includes drying the slurry after applying on the valve metal material.

110. The method according to Claim 108, wherein the valve metal material is roughened on the surface.

111. The method according to Claim 110, wherein the roughening of the valve metal material is performed by electrolytically etching.

112. The method according to Claim 110, wherein the roughening of the valve metal material is performed by chemically etching.

113. The method according to Claim 110, wherein the roughening of the valve metal material is performed by blasting sand technique .

114. The method according to claim 108, wherein said carbon embedding step uses a press method in which said

carbon particles are driven by using a die.

115. The method of producing an electrolytic capacitor according to claim 108, wherein said carbon embedding step uses a rolling method in which said carbon particles are driven by using a roller.

116. The method of producing an electrolytic capacitor according to claim 112, wherein the roller is an roller embossed on its surface.

117. The method of producing an electrolytic capacitor according to Claim 108, wherein the method comprises a step of coarsening the surface of said carbon-containing metal material.

118. The method of producing an electrolytic capacitor according to Claim 108, wherein the method further comprises a further step of exposing said carbon particles to the surface of said carbon-containing metal material by etching said carbon-containing metal material in an acidic aqueous solution.

119. The method of producing an electrolytic capacitor according to Claim 108, wherein the method comprises a step of exposing said carbon particles to the surface of said carbon-containing metal material by blasting said carbon-containing metal material.

120. The method of producing an electrolytic capacitor according to claim 118, wherein the method comprises a step of forming a passive film on the metallic surface of said carbon-containing metal material after said step of exposing said carbon particles.